From Biomass to Interface: Carob Pulp Sugar Extraction, Synthesis, Functional Characterization of new Cationic Sugar-based Surfactants

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The inevitable substitution of petroleum-based feedstocks is driving the scientific community towards the intelligent valorisation of biomass, such as carob pulp (*Ceratonia siliqua L.*), for the synthesis of new functional materials. As surfactants are among the most versatile and highly demanded chemicals worldwide, essential in pharmaceuticals, cosmetics, and detergents, shifting their production to renewable sources is a priority for sustainable chemistry [1,2] . In this context, carob pulp emerges as a strategic Mediterranean resource; although often undervalued, its exceptionally high sugar content provides a robust molecular platform for developing sugar-based surfactants [3] . By leveraging the natural sugar scaffolds present in this agricultural by-product, it is possible to engineer high-performance amphiphilic molecules that match or exceed the interfacial properties of their fossil-based counterparts, effectively closing the loop in a circular biorefinery model.
This work focuses on sugar extraction using ultrasound-assisted aqueous-acid conditions, designed to promote the *in situ* inversion of carob sucrose. The resulting sugar-rich extracts were comprehensively characterised by UV-Vis, GC-MS, and HPLC-RID, and subsequently employed as precursors for the synthesis of novel cationic surfactants. To validate the efficacy of the biomass-derived products, their physicochemical behaviour was evaluated and compared with benchmark surfactants synthesised from analytical-grade sugars. Furthermore, the functional potential of these new surfactants was assessed through antimicrobial activity assays against *Escherichia coli* and *Staphylococcus aureus* .

Keywords:
Carob pulp; Cationic surfactants; Ultrasound-assisted extraction; Acid hydrolysis; Surface activity; Antimicrobial activity.

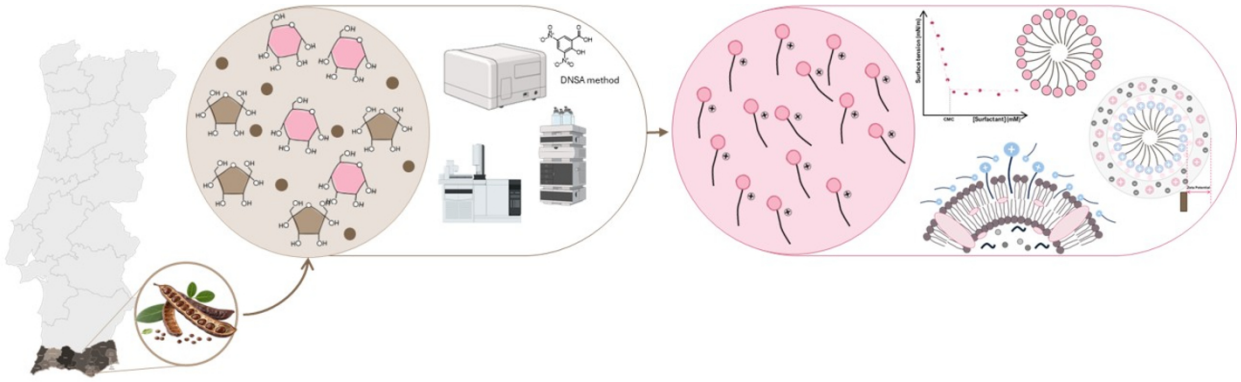

Figure 1. Synthesis and characterization path of new carob-derived cationic surfactants.

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